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PROCEEDINGS

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FIRE DETECTION FOR AIRCRAFT CARGO COMPARTMENTS , REDUCTION OF FALSE ALARMS

Abstract

In order to better understand the reasons for the current high false fire alarm ratio in Aeronautic Applications, an analysis of actual fire and false alarm events has been conducted using different database.

This research (funded by the European Commission within the 5th Framework Programme FireDetEx) included the following analysis :

1. **Analysis of false alarm cases**

   A review of false fire alarm cases extracted from different data bases will be presented, For some typical cases, it will be analysed whether the alarm was triggered by a system malfunction, particular environmental conditions or by the detection of aerosol particles.

2. **Analysis of fire alarm cases**

   Real fire alarm cases will also be considered, it will be determined what was the probable fire source, which phenomena has likely caused the ignition and what should have been the best fire sensor under these conditions.

3. **Definition of fire and non-fire scenario**

   The fire detection system can only be improved on the basis of clear performance objectives, fire and non-fire scenario will be presented against which the performance of new fire detection concept can be measured and evaluated.

Introduction

Among the various aircraft zones for which a fire protection is required, the cargo compartments are specific in this sense that their characteristics are very variable in

terms of dimensions and topologies as well as environmental conditions and fire threats.

Fire sources and their combustion mechanisms and products are diversified, therefore there is no single physical parameter that would allow the detection of this wide fire spectrum with an evenly distributed sensitivity.

Under these conditions, in the currently used systems, the smoke detectors have to be adjusted so as to early detect the fire type for which their sensitivity is basically the worst (and to meet the certification requirements [1]); making them also more sensitive to environmental conditions.

Basically, a combination of several criteria to trigger a fire alarm would bring a significant benefit in terms of discrimination capabilities, provided of course that the fire and non-fire situations are well known.

Therefore in order to improve significantly the fire detection reliability, it is necessary to better understand, under this environment, the physical parameters that distinguish the start of a fire from those that are due to non-dangerous phenomenon.

Analysis principle

Fire and false alarm events in operation were extracted from different data base [2] [3] and compiled as shown below:
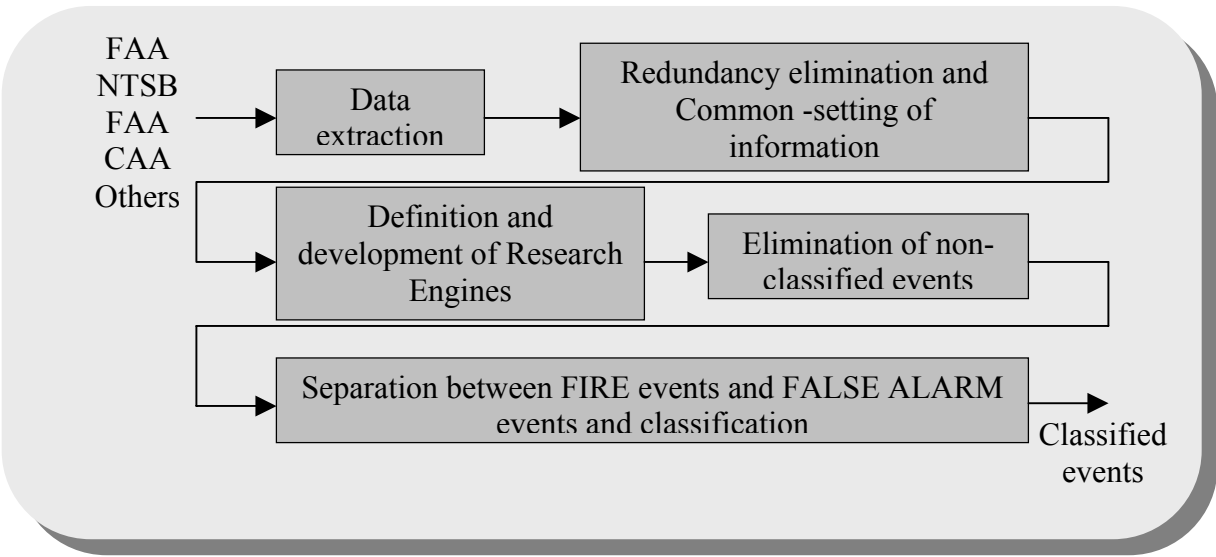
Figure 1 : Fire and false alarm events analysis

The following classification logic was applied :

Figure 2 : Events classification logic

It is to be noted that at the time of the event, most of the here-above information was not recorded (and practically impossible to retrieve after).
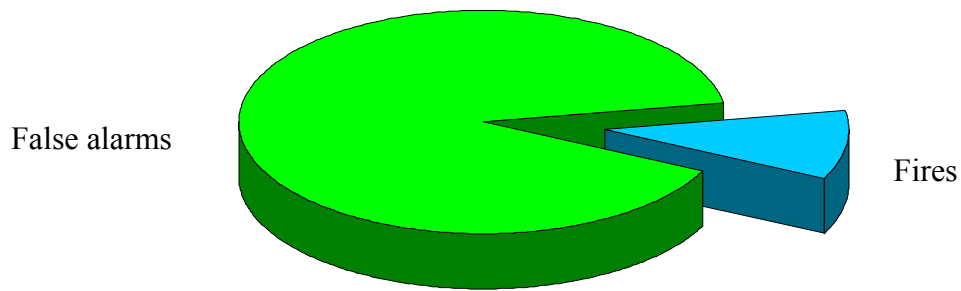
General outcomes

Figure 3 : Ratio fire/false alarm

In this graphic, regional aircraft are very few represented, the overall ratio (90% of false fire warnings) would be higher if this aircraft category was totally included [4].
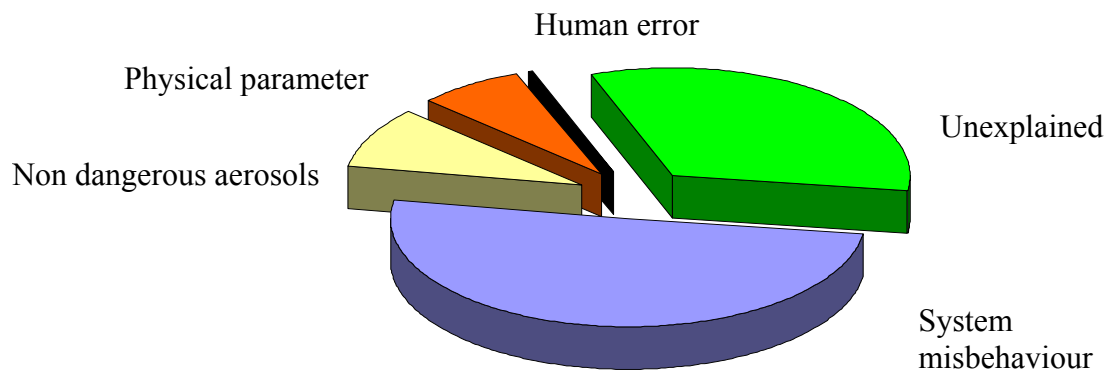

Figure 4 : False alarm analysis

In most of the cases, the conditions in the cargo compartment at the time of the alarm were not exactly known by the pilots or the crew, therefore false alarm events were often considered unexplainable or attributed to a system malfunction whereas a better knowledge of these conditions would have led to a different classification.

However, system misbehaviours under degraded situations (wiring failures, power supply failures, management of redundancies in case of internal failures, ..) take probably a significant part in the overall ratio and have to be considered as an improvement axis.

Analysis of typical false alarm cases

Event 1: Description

Date : 21/11/1985

Source : CAA (extract)

Aircraft Make : BOEING B-747

Carrier : NOT REPORTED

Phase Flight : CRUISE

Narrative : Lower aft cargo hold fire warning. A/c diverted emergency evacuation. False fire warning. Following a lower aft cargo hold fire warning a/c diverted to lajes where an emergency evacuation was effected. Some difficulty due to excessive force needed to open fully doors 2 & 4 l & 2 & 5 r. Several passengers sustained minor injuries. The cause of the fire warning was attributed to condensation emanating from a considerable quantity of 'warm' fruit. The two detectors were slightly oversensitive but this is considered a very minor contributory factor. A mod has been initiated to fit a dual loop smoke detector system.

Probable environmental conditions at the time of event 1

Physical parameter	Temp	Humid/ Condens	Radiat	Combust Aerosols	Other Aerosols	Comb gases	Other gases
Probable level	Low	High	Low	Low	Medium	Low	High

Event 2: Description

Date : 23/10/1998

Source : AIRBUS (extract)

Aircraft Make : AIRBUS A-340

Carrier : SABENA

Phase Flight : TAKE OFF

Narrative : At 4000 ft with configuration 1 forward cargo smoke red alarm came on. According to ec procedures the fwd cargo cooling was switched off. The switch was pre in max. One minute later the alarm went out. Visual check performed and confirmed neither smoke nor fire in the fwd compartment. Flight was continued. During cruise at flight level 290 lavatory sm warning came on. Toilet g1 triggered this alarm a lot of times. Visual confirmed nobody inside the toilet and no smoke evidence. Action: maintenance inspected fwd cargo and lavatory and did not find any indi of fire or smoke. Investigation related to oil smell in cabin revealed 3 oil quantity lower than on other engines. Suspected oil suction to air system. Deactivated engine 3 bleed system switch SDCU and smoke detector test were satisfactory. The next flights were also performed with engine 3 bleed off and oil consumption was monitored and found within limits. On ground in bru when switching APU bleed on smoke appeared in cabin cockpit. Smoke disappeared after switching off pack 2. Smoke did not with pack 2 on afterwards. Problems suspected to come from APU pneumatic duct. Maintenance found oil leak on filter bowl. O'ring replaced and leak check performed. Engine 3 bleed system was reactivated.

Probable environmental conditions at the time of event 2

Physical parameter	Temp	Humid/ Condens	Radiat	Combust Aerosols	Other Aerosols	Comb gases	Other gases
Probable level	Low	Low	Low	Medium or High	Low	Low or medium	Low

Analysis of fire alarm cases

Event 3: Description

Date : 20/03/1991

Source : FAA INCIDENT DATA SYSTEM

Aircraft Make : LKHEED L-188-C

Carrier :   REEVE ALEUTIAN AIRWAYS INC

Phase Flight :   FCD/PREC LDG FROM CRUISE

Narrative :   Dense fumes in cargo compartment. Diverted and landed. Smoke from box marked fish that contained batteries.

Probable environmental conditions at the time of event 3

Physical parameter	Temp	Humid/ Condens	Radiat	Combust Aerosols	Other Aerosols	Comb gases	Other gases
Probable level	Low	Low	Low or Medium	Medium	Medium or High	Medium	Medium or High

Event 4: Description

Date :   05/09/1996

Source :   NTSB AVIATION ACCIDENT/INCIDENT DATABASE

Aircraft Make :   DOUG DC10-10F

Carrier :   NOT REPORTED

Phase Flight :   CRUISE

Narrative :   The airplane was at fl 330 when the flight crew determined that there was smoke in the cabin cargo compartment. An emergency was declared and the flight diverted to newburgh/stewart international airport and landed. The airplane was destroyed by fire after landing. The fire had burned for about 4 hours after smoke was first detected. Investigation revealed that the deepest and most severe heat and fire damage occurred in and around container 6r which contained a dna synthesiser containing flammable liquids. More of 6r's structure was consumed than of any other container and it was the only container that exhibited severe floor damage. Further 6r was the only container to exhibit heat damage on its bottom surface and the area below container 6r showed the most extensive evidence of scorching of the composite flooring material. However there was insufficient reliable evidence to reach a conclusion as to where the fire originated. The presence of flammable chemicals in the dna synthesiser was wholly unintended and

unknown to the prepared of the package and shipper. The captain did not adequately manage his crew resources when he failed to call for checklists or to monitor and facilitate the accomplishment of required checklist items. The department of transportation hazardous materials regulations do not adequately address the need for hazardous materials information on file at a carrier to be quickly retrievable in a format useful to emergency responders.

Probable environmental conditions at the time of event 4

Physical parameter	Temp	Humid/ Condens	Radiat	Combust Aerosols	Other Aerosols	Comb gases	Other gases
Probable level	High	Low	Medium or High	High	Low or Medium	High	Low

Definition of fire and non-fire scenario

Some fire and non fire scenario are presented here-below as possible development tests for fire detection systems.

Fire cases	

• Open cellulosic fire (wood) : EN 54 - TF1 [5]
• Smouldering pyrolysis fire (wood) : : EN 54 - TF2
• Glowing smouldering fire (cotton) : : EN 54 - TF3
• Open plastics fire (polyurethane) : : EN 54 - TF4
• Liquid fire (n-heptane) : : EN 54 - TF5
• Liquid fire (methylated spirits) : : EN 54 - TF6
• Paper (UL268) :
  -Paper towels (open)
  -Scheduled newspapers (open)
  -Normal newspapers (open)
  -Normal newspapers (smouldering)
	• Cardboard boxes :
	  -Open cardboard fire
	  -Smouldering cardboard fire
	• Textile :
	  -60 % Wool / 40 % Acrylic (open)
	  -60 % Wool / 40 % Acrylic (smouldering)
	  -100 % cotton (open)
	  -100 % cotton (smouldering)
	  -100 % polyester (open)
	  -100 % polyester (smouldering)
	  -100 % wool (open)
	  -100 % wool (smouldering)
	• Jet A fuel fire
	• Diesel fire
	• Oil fire
	• Cable fire

Non fire cases :	
• Moisture • Condensation • Fog • Sand and Dust	• Fruit / Animals / Vegetables • Oil • Exhaust gas

Tableau 1 : Fire and non - fire scenario

Summary

The exploitation of actual fire alarm events is tricky because most of the time, the parameters recorded at the time of the event do not allow to determine the condition for which the alarms were triggered and can even lead to wrong conclusions.

However this analysis has allowed us to clarify some typical fire and non–fire situations and to outline performance tests accordingly.

Fire sources are extremely diversified and, in particular the materials involved are most of the time unexpected or even normally forbidden as cargo loads. As well their combustion products or effects are variable with, according to the event, predominance of different physical parameters.

False alarm sources are also diversified, in some cases the corresponding single physical parameters are very close to those that characterise the start of a fire.

Under these conditions, the adjunction of several detection criterion can increase considerably the discriminatory capabilities of the fire detection systems.

The dynamic of the various signals has to be taken into account in the fire alarm decision as an additional discriminatory factor, for this a minimum analysis duration is necessary which is very often not compatible with the current certification criteria (considering in particular the propagation time of the combustion products).

Performance development or qualification tests must be on one hand feasible under well controlled metrological conditions and on the other hand representative of a large range of realistic fire and non – fire situations.

References

[1] Schmoetzer, K . Aircraft Fire Detection: Requirements, Qualification and Certification Aspects, see this book of conference.

[2] FAA In service events Data Base.

[3]   NTSB In service events Data Base.

[4]   Blake, D. FAA Technical Center, Fire Safety Section, Report No DOT/FAA/AR-TN0029, June 2000.

[5]   EN 54-9 Components of automatic fire detection systems Part 9 Methods of test of sensitivity to fire".